PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in and relating to Means for Controlling the Liquid Masses of Tanks for Compensating the Rolling of Ships.

We, GESELLSCHAFT FUR ELEKTRISCHE APPARATE M.B.H., a German Company, of No. 44, Wilhelm V. Siemensstrasse, Berlin-Marienfelde, Germany, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The invention relates to means for controlling means for compensating the rolling of ships.

In order to increase the action of the compensating tanks for dampening the rolling of ships, it has already been proposed to so control the masses of liquid in the tanks by a separate drive, that they are moved backwards and forwards between the two sides of the ship in rhythm with the ship's rolling but with a phase displacement of 90°. In this an apparatus serves to control the masses of liquid, in which apparatus the deflections corresponding to the rocking angle, of a freely oscillating pendulum, act on gears with mechanical or hydraulic damping, the operating members of which are periodically adjusted corresponding to the values of the rocking angles but with a phase displacement of about 90° with respect to the movements of the pendulum, and consequently effect the regulation of the drive of the liquid masses. This control is both very complicated and expensive and, furthermore, it has too much inertia to attain in each case the phase displacement of the pendulum oscillations by exactly 90° necessary for perfect control. Furthermore, this control can in practice only be used for dampening periodical rocking movements. As soon as the ship is subjected to a list, this control has for effect that the masses of liquid are necessarily driven more and more to the lower side of the ship, so that a slight list of the ship once existing is increased to a much larger extent with this control than in the case where the masses of liquid in the tank are not controlled at all. It constitutes a serious danger for the ship if the masses of liquid which, as is known, are considerable in the tanks, are either not controlled at all or are controlled in an unsatisfactory manner as with the known arrangement. In order to overcome this danger, the tanks have hitherto been generally cut off by valves, and are only used when the rolling movements of the ship are approximately regular.

According to the invention, the drawbacks of the known control are obviated by the arrangement for regulating the feeding device, which is in communication with the tanks arranged on both sides of the ship, being adjusted in equal phase with the deflections of a rolling angle indicator, so that the feeding device is reversed when the ship passes through the horizontal central position, it being switched-in in one direction or the other when the ship is deflected from its central position towards one side or the other. The natural result of this is a movement of the liquid in the tank, which is displaced by 90° in phase with respect to the rolling motion of the ship. The regulating member may consist with electrical drive, for example of a controlling switch device, the switch arm of which is moved synchronously with the deflection of the apparatus measuring the angle of roll, or also of a two-way cock or the like inserted in the connecting conduit of two oppositely situated tanks, and which permits the connection as desired of the tank spaces with a suction and pressure pipe. In order to be able to put the tanks to work also in the case of slightly inclined positions, as for example in consequence of a list, and to control their masses of liquid in such manner that the lists are partially or wholly compensated, the regulating member for the driving force can, as a further development of the invention, be adjustable in addition to the measuring apparatus of the angle of roll, also by a device integrating over a certain time the angle of roll. With non-periodical rolling movements, an unsymmetrical distribution of the masses of liquid on both sides of the ship is

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thereby effected in such manner that these masses are, in a large measure, delivered to the side of the ship lying higher.

The invention is fully described below with reference to the accompanying drawings. Figures 1, 2 and 3 show different arrangements of compensating tanks on ships, the delivery apparatus of which is regulated by a control mechanism shown as an example in Figure 4.

In the arrangement shown in Figure 1, a constant mass of liquid is provided for the damping of the rolling movements, which liquid may, for example, consist of the store of oil of the ship. 1 and 2 are the tanks arranged on the sides of the ship, and which are in communication by means of the liquid conduit 3 and the air conduit 4, with check valve 5. In the liquid conduit 3 is arranged a reversible centrifugal pump 6 which is driven from the motor 9 through the gears 7 and 8.

According to Figure 2, the tanks 1 and 2 are arranged on the outside of the ship's sides. In this case, the tanks are filled with sea water which has free inlet through the openings 10 and 11. The air spaces above the sea water are connected by the pipe 4 in which is inserted a two-way cock 13 actuated from the shaft 12. By altering this cock 13, the tank spaces 1 and 2 can be brought into communication alternatively with the pressure space 14 and the suction space 15. Both spaces 14 and 15 are connected by a pipe 16, in which is connected a blowing pump 17 driven by a constantly running motor 18, and which continuously supplies air from the suction space 15 into the pressure space 14. The motor 18 rotates either at a constant speed or is automatically controlled in such manner that there is always a constant pressure in the pressure space 14 or in the suction space 15.

Figure 3 shows a further arrangement in which the tanks 1 and 2 are also fitted outside the longitudinal sides of the ship and are filled with sea water. In order to avoid connecting pipes across the whole ship, in this arrangement the air spaces of the tanks 1 and 2 are directly connected by pipes 19 and 20 with atmosphere. In the two pipes 19 and 20 blowing engines 21 and 22 are fitted which are driven by Ward-Leonard motors 23 and 24. The two Ward-Leonard motors are supplied by a common Ward-Leonard generator 25 which is driven by the continuously running motor 26.

In Figure 4 a controlling apparatus is shown by which the driving machines of the arrangements mentioned can be controlled and this for the case that, for example, the motor 9 in the arrangement according to Figure 1 is to be regulated by a controller circuit. The contact paths 27 and 28 of the controller circuit lying in the armature current circuit of the motor 9 are connected through resistances 29 and 30 to the direct current mains 31. On these is also connected the exciting winding 32. The controller switch arm 33 is moved backwards and forward directly by a motor 40, which follows the rolling angle indicator 41, through bevel wheels 34 and 35, shaft 36, differential gear 37, shaft 38 and bevel wheels 39. On this degree of control is superposed in the differential gear 37 a further control amount produced by the integrator 42, which amount corresponds to the integral of the roll angle over a certain time. Through bevel wheels 43 the movements of the motor 40 are transferred on to a threaded spindle 44, so that the spindle nut 45 is displaced backward and forward corresponding to the movements of the roll angle indicator 41. The movements of the spindle 45 are transmitted by the springs 46 and 47 to the hydraulic cylinder 48, the piston 49 of which is arranged at a fixed position on the piston rod 50. The hydraulic cylinder 48 is provided with a by-pass pipe 51 in which is fitted a throttle valve 52. On to the cylinder 48 is fixed a rack 53 which transmits the displacements of the cylinder on to the toothed wheel 54, and thence through bevel wheels 55 on to the differential shaft 56. The throttle valve 52 is so adjusted that the cylinder 48 only slightly follows the movement of the nut 45 as long as the displacements of the nut 45 take place symmetrically to the middle position shown. In this case, which corresponds to the regular rolling movements, only a small regulating value is transmitted from the integrator 42 on to the differential gear 37.

In order to attain a complete damping of the rolling movement, it is necessary that the shifting of the masses of liquid in the tanks follows the movement of the ship as a rule exactly by 90° out of phase, and consequently that for example in the arrangement according to Figure 1 the motor is stationary, in the central position of the ship as shown, after it has so distributed the liquid that this is higher in the tank 1 than in the tank 2 when the ship rocks in the clockwise direction, but that it is higher in the tank 2 than in the tank 1 when the ship rolls in counter clockwise direction. As now the angle of roll indicator 41 is deflected

synchronously with the movement of the ship, the arrangement according to Figure 4 is so contrived that the movements of the controller switch arm 33 are substantially in phase with those of the roll angle indicator 41. The reversing position shown of the controller switch arm 33 corresponds to the horizontal position of the ship, while the motor 9 has its greatest speed at the moment when the angle of list of the ship is at its maximum and drives the masses to the lower side of the ship, just commencing its upward movement. The method of operation of the control gear according to Figure 4 is such that as long as there are entirely regular rolling movements, practically only the control movement of the roll angle indicator 41 transmitted directly through the shaft 38, acts on the controller switch arm 33. The damping constant of the integrator 42 is so adjusted by the throttle valve 52 that the periodical displacements of the spindle nut 45 are only transmitted to a small extent on to the shaft 56. This regulating amount given by the integrator 42 follows that of the rolling angle and is subtracted from the latter in the differential gear 37. Consequently, the deflections of the arm 33 no longer take place exactly synchronously with the deflections of the ship, that is to say with the deflections of the indicator 41, but precede these deflections slightly to such an extent as is necessary for the acceleration and retardation of the inert motor and liquid masses.

In order to explain how the movement of the masses of liquid is phase-displaced by 90° in relation to the list of the ship, however, the inertia of the masses to be displaced and thus of the integrator 42 is not to be taken into account and it is to be assumed that the switch arm 33 is adjusted in completely equal phase with the deflections of the indicator 41. In the zero position shown in Figures 1 and 4, the height of the liquid in the tanks 1 and 2 is equal, the switch arm 33 (Figure 4) standing in its central position. If a rolling motion now commences, the tank 2 moving downwards first, the switch 33 is deflected, for example, to the right, whereby the motor 9 is switched in in such a sense that the pump 6 feeds liquid from the tank 1 into the tank 2. The motor 9 remains switched in until the tank 2 and consequently the switch arm 33 again pass into their central position; the liquid in the tank 2 therefore then stands higher than in the tank 1. In the ensuing period, when the tank 2 swings up out of its central position and back again, the switch arm is deflected to the left, so that the motor revolves in the opposite direction and the pump 6 consequently feeds liquid from the tank 2 into the tank 1 during the whole of this time. The tank 2 then swings down again and back into the central position shown and, at the same time, the switch arm 32 is again deflected to the right and back again, so that the motor with the pump 6 again empties the tank 1 and fills the tank 2.

The result of this is that the level of the liquid in the tank 2 is highest as this tank passes upwards through the central position shown and lowest when the tank 2 passes downwards through the central position shown. In the tank 1 the movement of the liquid takes place in the correspondingly inverse manner. When the ship and consequently the switch arm 33, on the other hand, have made their greatest deflection, the liquid in both tanks stands at an equal level. This means that the liquid motion in the tanks 1 and 2 always takes place in the opposite direction and is thus displaced in phase by 90° in relation to the movement of the ship. It is thereby brought about that upon the reversal of the rolling movement at the moment when the ship is in the position of greatest deflection (when the angular velocity of the ship is zero) the liquid in both tanks stands at an equal height, so that no damping force is present. On the other hand, when the ship moves with its greatest angular velocity through the central position shown, the tank moving upwards is completely or approximately filled and the tank moving downwards is entirely or approximately emptied, so that the entire or approximately the entire quantity of the liquid in the tanks is effective as a damping force.

If, as is practically always the case, a periodic rolling movement takes place, then if there were no integrator, the unequally large deflections of the roll angle indicator in the two directions would so control the motor that this would drive the masses of liquid constantly more to the lower situated side of the ship. Now, however, the periodical displacements of the spindle nut 45 towards the one side, for example, to the right, are considerably greater than towards the other side. Consequently the centre position of the spindle nut 45 is also displaced to the right by an amount corresponding to the mean inclined position of the ship, and when this inclined position continues, the hydraulic damping cylinder 48 is also so displaced. The shaft 56 will therefore now transmit not only the small regularly

acting amounts in the negative sense, on to the controller switch arm 33, which previously effected the necessary advance reversal of the motor, but in addition, a negative control amount continuously corresponding to the inclined position, whereby the total regular movement of the switch arm 33 is so displaced that the motor 9 is now switched in longer for those half periods when the liquid is driven from the tank lying lower in consequence of the mean inclined position, into the higher situated tank, than in the following half periods when the liquid is pumped from the higher situated into the lower situated tank. As soon as, owing to this shifting of the weight, the inclined position of the ship is compensated, the unsymmetrical action of the integrator 42 on the regulating member of the motor 9 will also cease.

If there were no rolling movement but simply a list of the ship, then as will be easily seen the control would keep the motor 9 rotating until the pump 6 had delivered sufficient liquid to the higher situated side of the ship to again restore the horizontal position of the ship. As a rule, the tanks will naturally not have sufficient contents to be able to compensate lists or the like caused by leaks or the like. In this case, however, tanks situated in the centre of the ship with fuel oil stores can be caused to help the control, the pump now delivering the liquid from these reserve tanks into the tanks of the side of the ship lying highest.

The arrangement described can also operate in the reverse manner, that is, for the production of rolling movements instead of for their dampening, as is sometimes necessary for exercising or trial purposes. In this case, the liquid masses instead of lagging by 90° with respect to the movement of the ship, must lead by 90°. The entire control arrangement must therefore be displaced by 180° in phase. This can easily take place by the terminals of the armature or of the stator being changed on the motor 9. Otherwise nothing is altered.

It is of course easily possible instead of the hydraulic integrator to use other known integrators.

Instead of the described regulating members and driving machines, others of known character may also be used. The control shaft 36 (Figure 4) could, in the arrangement according to Figure 1, also serve for the adjustment of the blade wheels of the pump 6 when the motor 9 could run at a constant speed. In the arrangement according to Figure 2, the control shaft could, for example, be in direct connection with the shaft 12 of the two-way cock 13, while in the arrangement according to Figure 3 it could influence the regulating resistance for the field of the Ward-Leonard generator 25. The potential produced by the generator 25 would then always be proportional to this control value, so that the two Ward-Leonard motors 23 and 24 connected displaced with respect to each other by 180°, drive the reversible pumps 21 and 22 in such manner that one always delivers air outwards when the other pumps air into the tank. In principle, the method of operation of this arrangement is, of coure, the same as if the air spaces of the tanks 1 and 2 were connected together by a pipe in which was inserted a single supply machine controlled by the controlling apparatus according to Figure 4.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for displacing the quantities of liquid in tanks arranged on both sides of the ship by means of a feeding device communicating with the two tanks, for the purpose of compensating the rolling motion of the ship, characterised by the fact that the regulating device of the feeding device is displaced in like phase with the deflections of the rolling angle indicator, so that the feeding device is reversed when the ship moves through its central position, while the feeding device is switched-in in one sense or the other when the ship is deflected in one direction or the other from its central position in such a manner that the liquid movement in the tanks is displaced in phase by 90° with respect to the rolling motion of the ship.

2. Apparatus as claimed in claim 1, characterised in that the regulating device for the feeding device receives a supplementary displacement from a device which integrates the rolling angle with regard to time.

3. Apparatus as claimed in claims 1 or 2, characterised in that feeding device is electrically driven, a controller switch device being provided as the regulating mechanism, the switch arm of which is capable of displacement in like phase with the throw of the rolling angle indicator and simultaneously with the apparatus which integrates the rolling angle with regard to time.

4. Apparatus as claimed in claim 3 wherein the feeding device comprises a Ward-Leonard generator, to which are connected one or more driving motors for

the devices moving the liquid masses.

5. Apparatus as claimed in claim 1 or 2, wherein a two-way cock or the like fitted in a connecting pipe is provided as the regulating member, for permitting the alternative connection of the oppositely disposed tanks with a suction or pressure pipe.

6. Apparatus for displacing liquid masses in tanks for compensating the rolling of ships substantially as herein described with reference to the accompanying drawings.

Dated this 1st day of June, 1931.

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Fig. 1

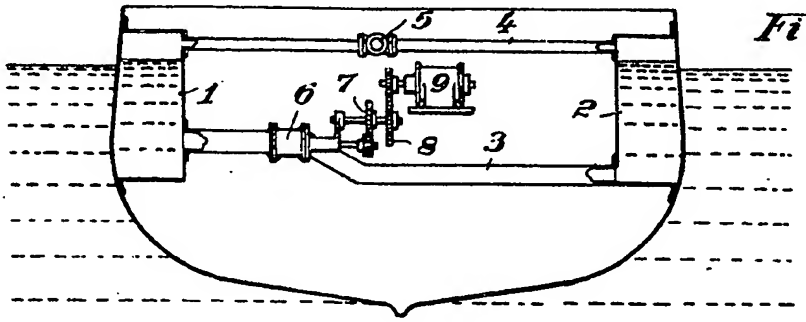


Fig. 2

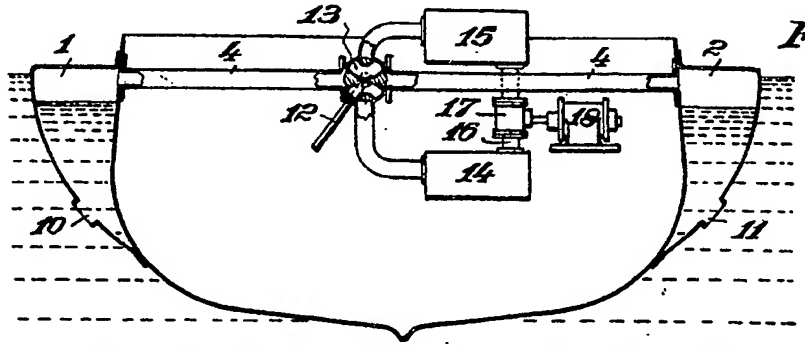


Fig. 3

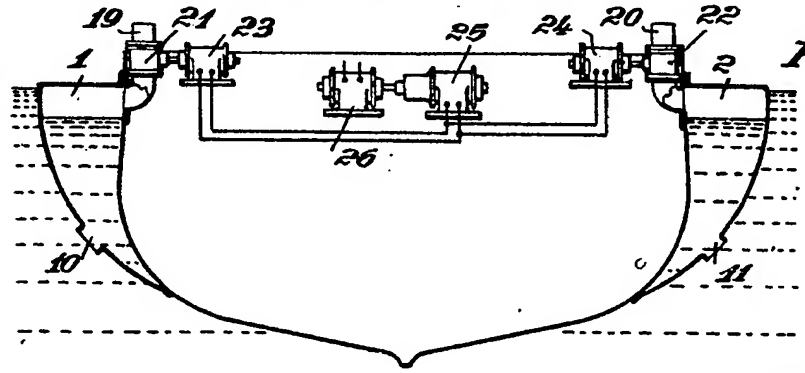
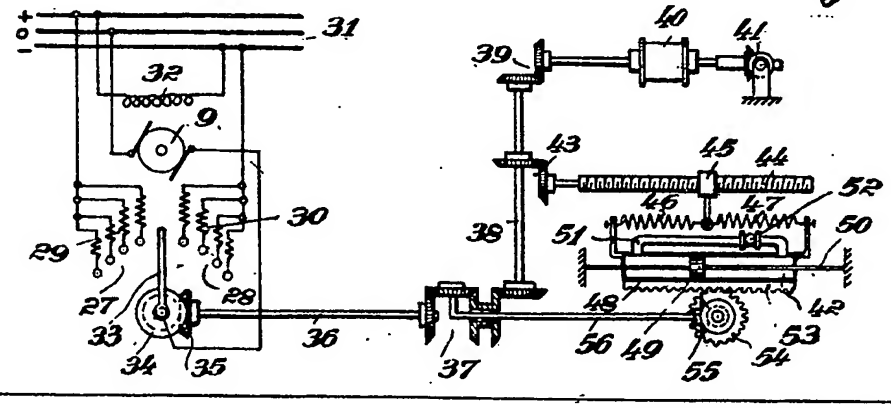


Fig. 4



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